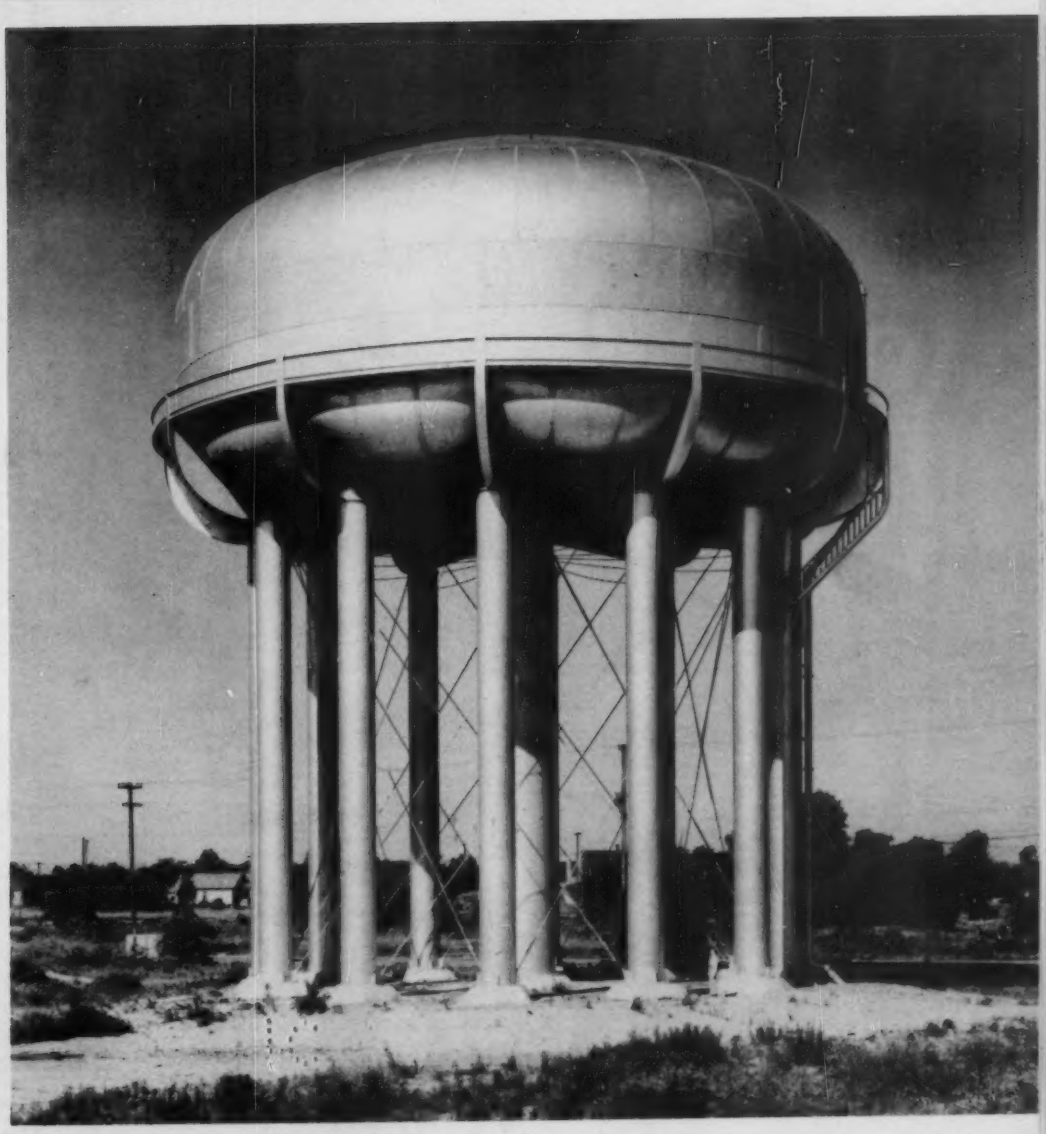
TECH ENGINEERING NEWS



FEBRUARY · 1940

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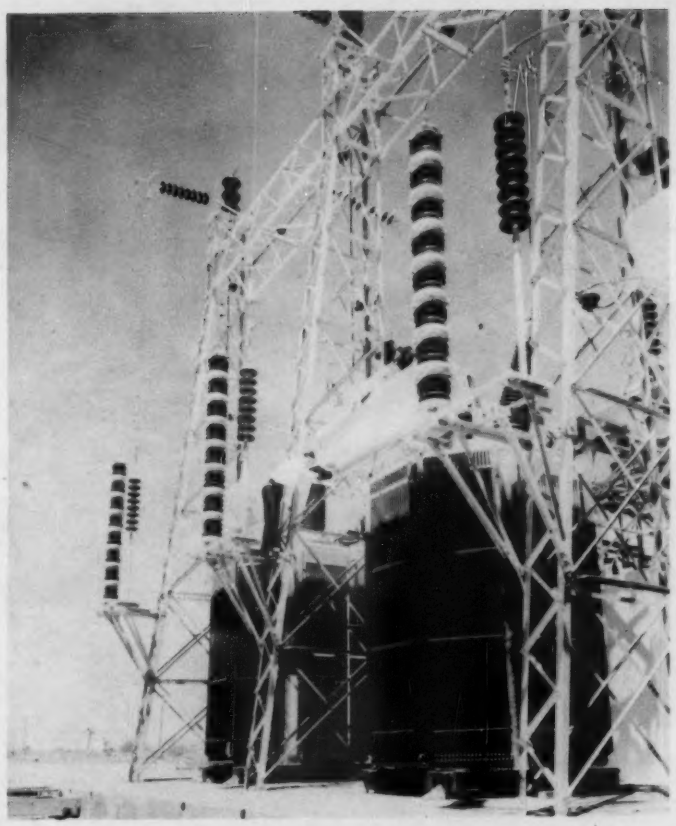

Allis-Chalmers

OUR COVER THIS MONTH shows a 1,500,000-gallon Colonial design gravity pressure water tank.

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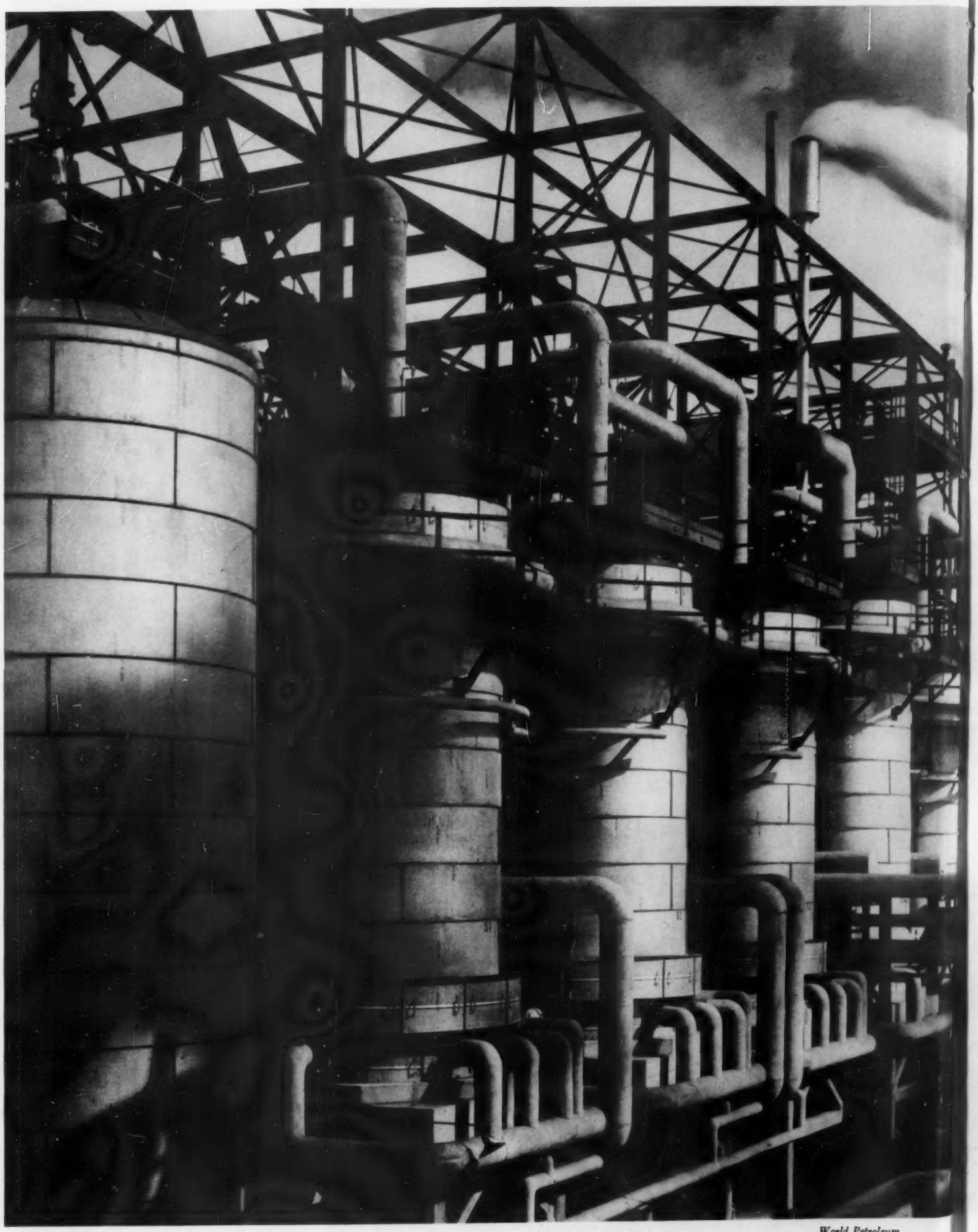


World Petroleum

Catalyst Cases at a Houdry Plant

GIFT OF PUBLISHER
MAY 17 1941

Catalytic Petroleum Cracking

PREMIUM PERFORMANCE GASOLINE FOR THE PRICE OF REGULAR

By A. CARLETON JEALOUS, '42

A LITTLE over a year ago a group of oil refiners sat in the banquet hall of the Stevens Hotel in Chicago waiting to hear about a process that conceivably might result in revolutionizing their industry. The occasion was the nineteenth annual meeting of the American Petroleum Institute and the speaker was Arthur E. Pew, Jr., Vice-President of the Research Division of the Sun Oil Co. of Philadelphia. The group had collected especially to hear the first public announcement of a new petroleum cracking process. Mr. Pew spoke about what automobile owners are talking about all over the country at the present time — a new gasoline made by a new process and giving premium performance, yet selling for the price of regular gasoline.

Mr. Pew was presenting to his listeners an explanation of the Houdry processes which concern principally the catalytic processes for petroleum-hydrocarbon refining. They involve complete catalytic operations for production of high octane motor fuels and aviation gasolines by cracking gas oils, residuum, and crude oils with or without producing fuel-oil. The Houdry process obviates the expense of adding tetraethyl lead to raise the octane value of raw gasoline stock.

In fact, Sun Oil has never added a drop of tetraethyl lead to the gasoline it has marketed, as have practically all of the other refiners. It formerly produced high octane, or "premium," gasoline by very careful methods of processing selected crude oils. At the same time, a constant lookout was kept for a process which would eliminate the growing possibility of having to use tetraethyl lead. It is quite conceivable, in fact probable, that tomorrow's cars will have higher compression engines necessitating higher octane gasoline for their satisfactory operation. This is exactly what Sun Oil was pondering over when Eugene Houdry came to that company a few years ago. Having offered his process to practically every large oil company in the United States, as well as some in his native land and elsewhere, and having received generally only a polite interest, he was, of course, overjoyed at Sun's warm welcome. Soon Sun Oil, with Socony-Vacuum, in conjunction with the Houdry Process Corporation, began industrial development of the processes. Working with them on plant construction were E. B. Badger & Sons Co., construction engineers and the sole licensing agents for the processes, who to date have built nine domestic plants and the single foreign plant.

The accompanying flow sheets show how the Houdry process and the conventional thermal method operate, and what their main difference is. Both flow diagrams are very simplified — especially the thermal diagram — since more detailed sheets can not be discussed in this space. Thus the reader can see diagrammatically how M. Houdry's process operates on an industrial basis. What, the reader may ask, is the origin of the process?

The story of how Eugene Houdry developed his process is one of frustrated patriotism, of forsaking a secure career in his father's steel business, and of an honors graduate in mechanical engineering turning chemist. France has very little oil but an abundance of lignite, or brown coal, a low-grade hydrocarbon. In 1922, a widespread scare of an imminent European fuel shortage plus a chance meeting with a man who had obtained a small amount of gasoline from lignite took young Houdry away from his father's steel business. At the same time, La France was breaking her back to import Iraq crude, a poor cracking stock which is high in sulphur content. (Sulphur is what literally "gums the works" in your car if it is present in appreciable amounts in the gasoline. The more sulphur that is present in the crude the more difficult it is to remove.) Houdry determined to save his country from its predicament. Working with other chemists, he attempted by devious means to obtain gasoline by distillation of lignite and passage of the vapors through a catalyst. The main difficulty in these attempts lay in finding a catalyst which sulphur would not foul too easily. The entire search for a suitable catalyst was necessarily empirical. Finally, it was discovered that by passing air through the catalyst and burning the sulphur deposit, the catalyst was regenerated. Continuing to search for a more practical catalyst, Houdry eventually tried aluminum silicate. This is the preferred base material used in the industrial process today. Empirically determined amounts of nickel, copper, or manganese may be added to modify the catalyst as desired.

At one point in the experimental stage, Houdry tried some of the new gasoline in his racing car. He ran the car up to 90 m.p.h. and is reported to have remarked, "The engine felt as though it were running in absorbent cotton." This test showed that gasoline from his new process could deliver higher power, cause less knocking in high-compression engines, and be derived from low-grade crudes.

In 1929 an unsuccessful attempt was made under government subsidization to run the process on a profitable industrial basis. A plant was built and put in operation; but because many difficulties were encountered with a resultant financial loss, the French government refused to have anything more to do with the process.

Then followed years of fruitless attempts to interest refining companies in other parts of the world to develop

the process. Vacuum Oil of New Jersey was the first in this country to show interest, with the result that the Houdry Process Corporation was formed. Shortly afterwards Vacuum was merged with Socony and the Houdry development was delayed again. Finally, M. Houdry interested Sun Oil in carrying on the work. Then Sun Oil and Socony-Vacuum got together and began the work of putting the laboratory processes on a large-scale basis.

To appreciate the value of the Houdry processes to refiners, one should know something of the general nature of petroleum and of conventional methods of processing it. Petroleum is a highly complex material consisting of countless thousands of overlapping compounds of hydrogen and carbon plus many impurities such as sulphur. In the thermal cracking of these heavy molecules a certain number of the latter recombine to form a residue of asphalt and fuel oil known as "heavy bottoms." (Some refineries have attempted to remedy this situation by hydrogenation, but this method is at present too expensive for commercial operation.) The catalyst in the Houdry process eliminates the recombination of the decomposed heavy molecules. The catalyst, a mixture of silica and alumina obtained from fuller's earth, a cheap, abundant material, is used in the form of a stringy, pinkish mass. The crude oil is vaporized and forced through the catalyst, which appears to speed the decomposition of the heavy molecules into lighter molecules and to prevent the latter from reforming into their previous state.

From present thermal cracking equipment a gasoline yield of only about 44 per cent is obtained, though some authorities believe that with new equipment this yield could be stepped up to 65 per cent. Half of the remaining 56 per cent represents "heavy bottoms," which show the smallest return on any refiner's statement of gross sales. Therefore, in order to produce the quantity of gasoline required by the market, the nation's oil wells were being heavily taxed; in the summer refiners were building up huge fuel oil surpluses to meet the peak demand of the gasoline market, and vice versa in the winter to meet the peak fuel demand.

Furthermore, gasolines from thermal cracking rate only about 60–70 in octane value. It is therefore necessary to boost this value by adding tetraethyl lead to around 71 for regular gasoline and about 79 for the premium product. Another important short-coming of the thermal cracking process is its restriction upon the quality of the crudes that can be handled efficiently.

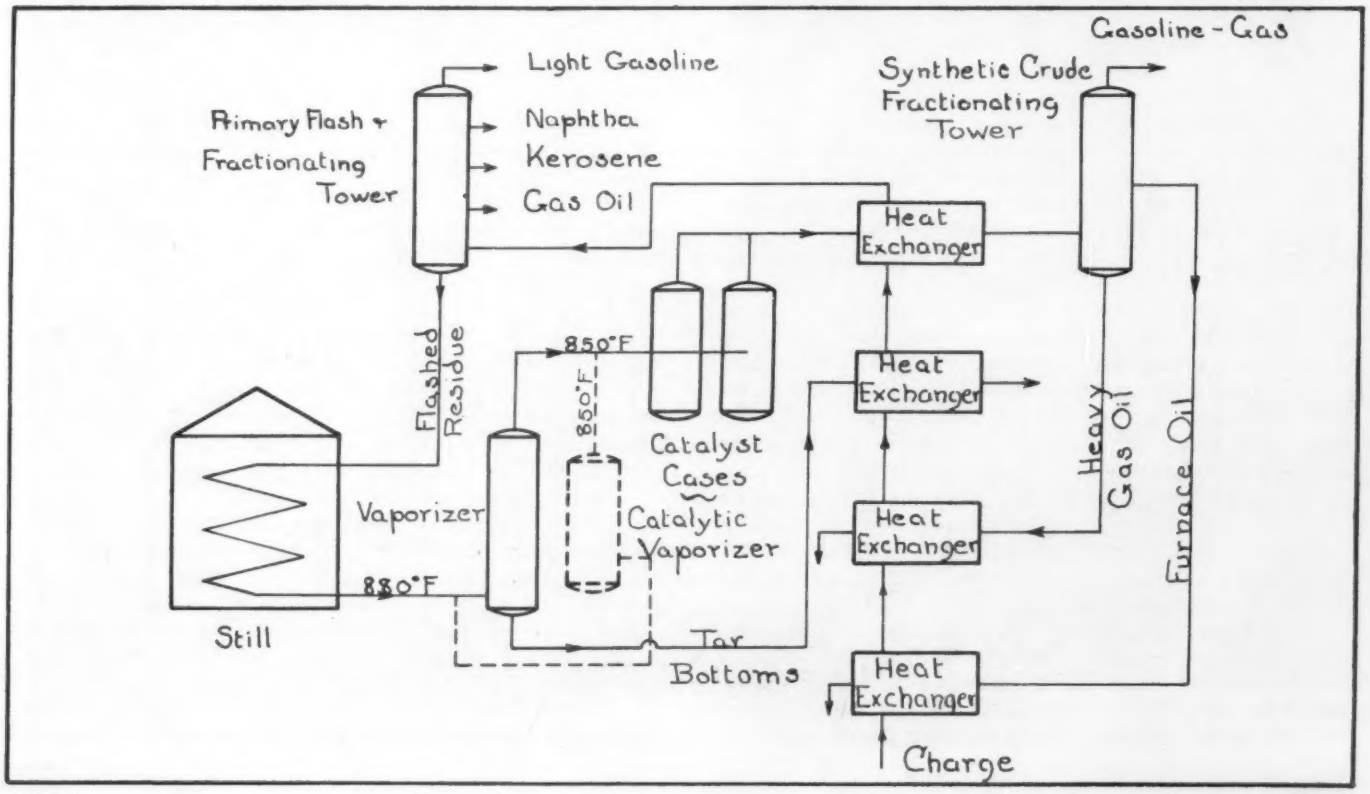
From the lowest grade crudes and refinery residuum, a high-grade gasoline yield of about 80 per cent can be obtained by the Houdry process without the production of profitless heavy fuel oil. Half of this gasoline yield, which is taken after the first pass, has an octane rating of 78 to 80. The residuum must then be reprocessed to produce additional high-grade gasoline.

In the physical operation of a Houdry unit there are advantages over the thermal process in that temperature requirements are not so high and the pressures are considerably less.

In developing the principles of design and construction of full-scale commercial apparatus, Sun's engineers had to solve the problem of periodic regeneration of the catalyst. There are several catalysts used, differing only in the composition of the aluminum silicate according to the service required of them. They are moulded under pressure, dried, and baked, to produce solid units

Crude oil is pumped through the heat exchangers for pre-heating by the products of the catalyst cases. The charge then passes to the primary flash fractionating tower, from which fractionated straight-run products are removed. The residue is pumped through a still, where it is heated, and thence to a vaporizer. From this chamber, tar bottoms are drawn off, while the vapors pass on through the catalyst to the heat exchangers and then to the final fractionating tower. The catalyst breaks the heavy molecules into lighter ones and prevents recombination of the latter to the former state. Several short cuts can be made along the line depending on whether the starting charge is virgin crude or previously passed stock. Also, to eliminate fuel oil production, the charge from the still passes directly to the vaporizer shown on the dotted line. A special catalytic mass vaporizes the entire charge before it passes through the regular catalyst for the final stage of the operations.

The gasoline and gas from the final tower pass through a condenser to a stabilizer (not shown) and thence to storage.

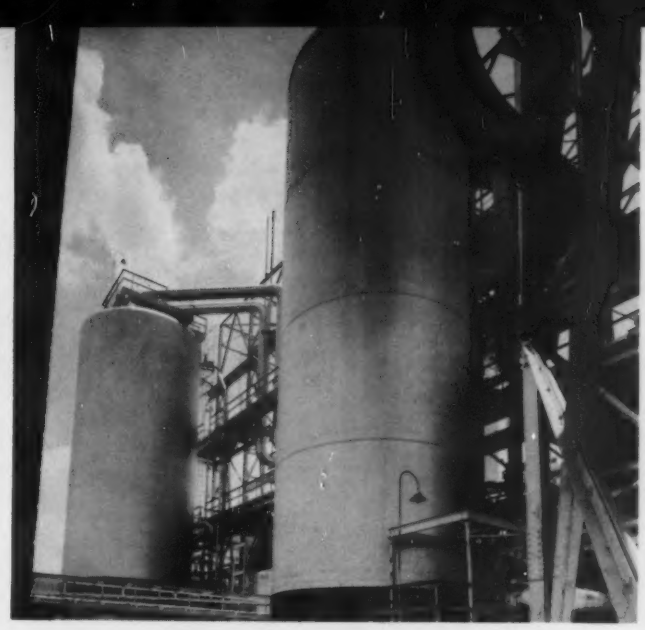


or cases. These cases are operated in pairs: when one becomes fouled, master timing devices controlling the whole operation cause the other case to be put into use. Thus, while a constant flow of charge is maintained, the fouled case is subjected to a blast of hot air which burns off sulphur and carbon. Current operations appear to show that the catalyst's life is unlimited.

To make these operations feasible the engineers had to figure the velocity of the vapor passing through the catalyst, the volume of vapor flowing through a given shape and size catalyst, and the exact timing of the valves. For obvious business-economic reasons, provision was made for the recovery of the heat from the products of regeneration as steam and as electric power — the latter by a heat turbine coupled to an electric generator. It is thus possible for the average catalytic-cracking unit to produce its own electricity and steam.

Sun Oil believes Houdry's process means a great saving to aviation which requires a 100-octane gasoline. Even when high-grade crudes, which are relatively scarce, were thermally cracked, a straight-run gasoline from this direct distillation rated only 73 in octane value. It requires treatment with appreciable amounts of tetraethyl lead and iso-octane, a pure petroleum hydrocarbon, which is used as a rating standard and which is by definition called 100-octane rating. Houdry gasoline needs only one half as much iso-octane. For example, a 100-octane gasoline, Army method blend, consists of about 25 per cent iso-octane, 75 per cent Houdry aviation gasoline, and 2.75 ml. of tetraethyl lead. It is not necessary to have special, or separate, equipment as a source of Houdry aviation gasoline.

Millions of dollars have been invested in numerous large operating plants and new Houdry plants are being built or projected at the present time. Coupling this with the fact that a decidedly larger proportion of the raw material is transformed by the Houdry process into the two money-making products — gasoline and gas oil — and the fact that their quality exceeds that of the thermally cracked products, one can understand why the refining industry is particularly interested in the Houdry processes today. Incidentally, according to one estimate, a Houdry unit will earn all plant and royalty charges in less than three years.

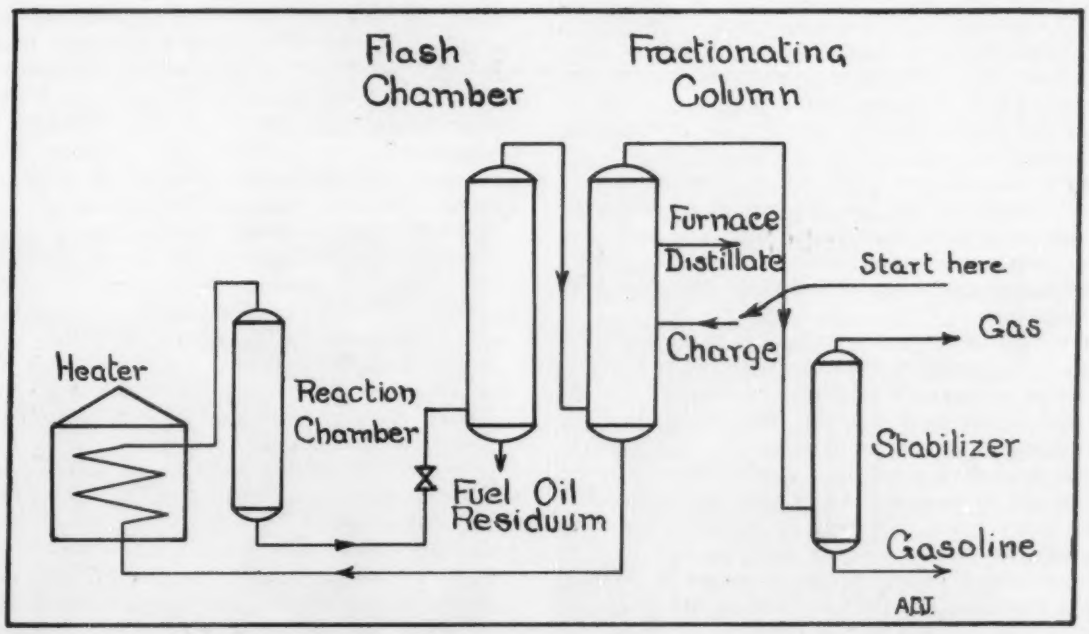


National Petroleum News

Fractionator Columns of a Houdry Unit

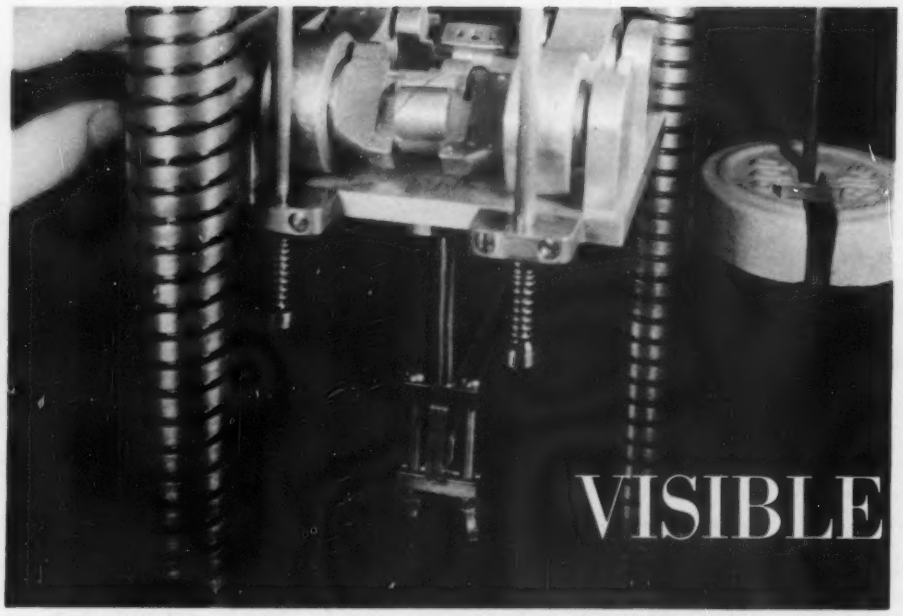
Sun Oil's plants at Marcus Hook, Pa., and Toledo, Ohio, are the largest units in operation at present. Socony-Vacuum has three large units in operation and three building. The Magnolia Petroleum Company has two large units at Beaumont, Texas. At the present time, there are several smaller units being built abroad by foreign interests.

When the Sun Oil Company and the Socony-Vacuum Oil Company complete their program for fifteen new plants by the end of 1940, the throughput of these units will be equivalent to about 10 per cent of the crude throughput of all the refineries in this country.



THERMAL CRACKING PROCESS

Oil is pumped into the fractionating tower where condensation of the vapors takes place. The heavy fractions are passed through the heater, thence to the reaction chamber where the mixture is cracked at about 920 degrees F. The charge flows from this unit to the flash chamber at reduced pressure, where vapors and liquid residuum separate. The hot vapors pass through the heat exchanger to the fractionating tower where gasoline, light oil fractions, and heavier condensates separate. The gasoline passes to a stabilizer, thence to storage.



VISIBLE STRESS

Figure 4. Bakelite Ring with Load at Opposite Ends of the Vertical Diameter

PHOTOELASTIC METHODS SOLVE THE ENGINEER'S PROBLEMS IN STRESS ANALYSIS

By WILLIAM M. MURRAY

IN this era of rapid progress engineers and scientists are continuously being called upon to develop new ideas and to improve the applications and understanding of principles which are already well established. One frequently hears that some new product or process has been developed by a group of research workers, but in reality this one development is merely the integration of the results of a great many smaller investigations. This coördination of the fruits of research in many fields is well illustrated by the modern giant airplanes in which new materials, new procedures and tools for fabrication, more precise methods of design, and better trained brains have all contributed their share towards the final success.

Whenever an important structure is to be built, be it large or small, an engineer will be required to investigate the forces acting upon it, and then from his knowledge of these forces to design the component parts to give the greatest economy consistent with safety. Usually the final design will be a compromise between a mathematical stress analysis and previous experience. There are many cases, however, in which other than mathematical methods of stress analysis will lead to more precise results. Where saving of weight is essential one should therefore use that method of investigation which seems best suited to the problem at hand. In recent years much valuable information has been collected by means of tests on models, usually in some reduced scale relative to the prototype.

In this last classification one finds the Photoelastic method of stress analysis. The method can hardly be called new, since its principle was discovered over a hundred years ago, but like many other discoveries its practical application was not accomplished until considerable research had been undertaken on materials and equipment. Today it is a powerful tool which can be easily used with little expense by any designing engineer. The principle of operation depends upon the fact that certain materials when subjected to stress behave temporarily as crystals and polarize light passing through them in the directions of the principal planes of stress. Not only does this directional effect take place, but the passage of the light through the material is affected in proportion to the intensity of the internal stress. Let us consider the mechanism of this effect in a thin plate model (of photoelastic material) when the applied external forces all have their lines of action contained in the mid plane of the plate. This is known as a condition of plane stress. If a beam of polarized light is passed through the model perpendicular to its own plane, the model will re-polarize the light into two components, one in the direction of each principal stress. If these principal stresses are of unequal magnitude, the components of the light will pass through at different rates and emerge out of phase. This phase difference is very closely proportional to the difference between the principal stresses and it can be measured easily by bringing the emergent components of the light into interference in a single plane. This may be accomplished by passing the light through a polarizer following the model. The image projected on a screen will then show a brightly colored pattern if white light is used or a pattern of black lines if monochromatic (one wave length) light is used.

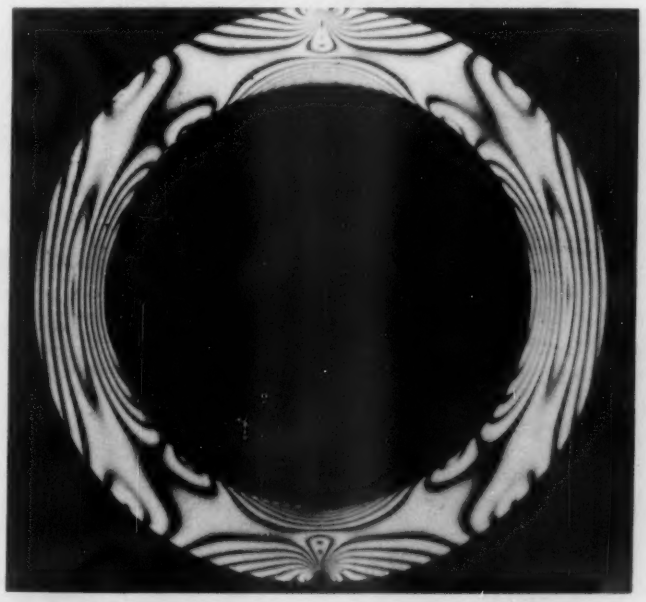
Undoubtedly the lack of suitable materials for models and the difficulty in obtaining large fields of polarized light must have retarded the application of photoelasticity to engineering problems. However, both of these difficulties have now been overcome and one may conveniently use this method of stress analysis with little expense and no more complicated mathematics other than simple arithmetic. The original investigations were carried out with glass models and involved the tedious process of matching colors at every point at which the stress was desired. The introduction of celluloid and later the highly sensitive synthetic resins has entirely revolutionized the stress determination, since these newer materials when used with monochromatic light permit the photographic recording of the whole stress condition in the model. This new procedure not only investigates every point in the model at the same time, but in addition it provides a permanent record of the complete stress picture. Figure 1 illustrates this modern technique with what is called a fringe photograph. From this one can obtain the difference between the principal stresses or maximum shear stress at any point in the model, but along the free boundaries one can even do better than this because the principal stress at right angles to the boundary is zero and the difference gives the other principal stress directly.

From Figure 1 one realizes at once that the pattern means something, but how can it be interpreted in terms of stress? This is a very easy process for one merely has to determine the order of interference at any point in question, multiply this by the fringe constant, and divide the product by the thickness of the model in the direction of the path of the light. The order of interference can be found by observing the model as it is being loaded. During this process the fringes or dark bands increase in number and in so doing move from one position to another. One notes some point and then counts the fringes as they pass over it. For example, if four fringes pass the point, then the last to pass it corresponds to the fourth order of interference. The order of interference of each fringe follows consecutively up or down from its neighbor, so that if the order of one fringe is determined then the order of all the others can be found. The fringe constant is the stress intensity which must be applied to a tensile model of unit thickness (in the direction of the path of the light) in order to produce one order of interference, and this is found by direct calibration. As a numerical example, let us consider a point at which we have the fifth order of interference in a model whose thickness is .330 inch. Then, if the fringe constant for this material is 86 pounds per inch per order in light of the same wave length, the difference between the principal stresses at this point will be

$$\frac{5 \times 86}{.330} = 1{,}300 \text{ pounds per square inch.}$$

If the point happens to be on a free boundary, this is the stress at the point.

Figure 1. Fringe Pattern in Vibrating Beam 51 Cycles per Second



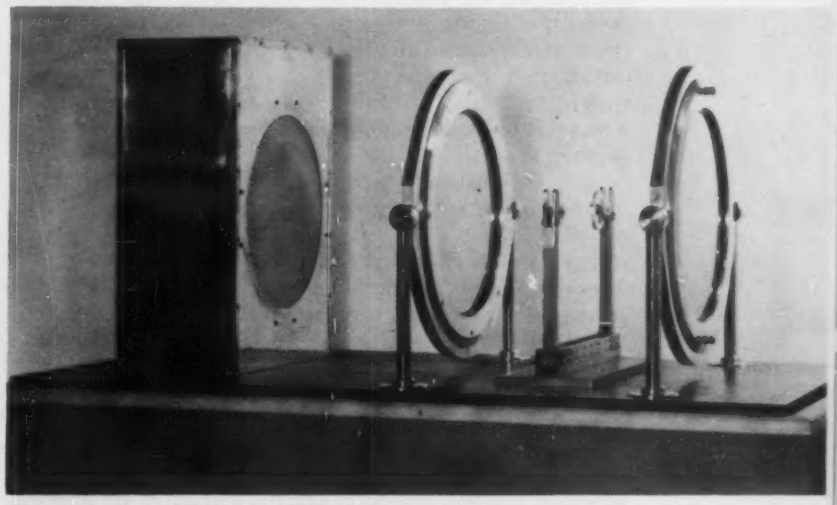


Figure 2. Portable Large Field Polariscope

Although many materials with photoelastic characteristics are now commercially available, they all possess some disadvantages. One is therefore forced to make a compromise in one's selection of material for the model by balancing the good qualities against the undesirable characteristics. In this country, transparent Bakelite (BT-61-893) is the material in most common use. It is highly sensitive to stress, machines easily, possesses linear stress-optical and stress-strain relations and reasonably good strength. Against these desirable properties it shows some tendency to creep at the higher stresses, and models made of it deteriorate rapidly with time due to the development of a residual edge effect which cannot be eliminated entirely by annealing.

In regard to the equipment required for making the photoelastic analyses one may say that its primary requirement is to produce a large beam of polarized light in which the model can be conveniently examined. Of the various methods which may be used to produce the polarization of light, until recently, the majority of the installations for optical stress analysis have employed the nicol prism which is a crystal of calcite split diagonally and glued together with a transparent cement. The degree of polarization which can be obtained in this manner is excellent but the size of the field is very limited, as a prism capable of transmitting a beam of light one inch in diameter is considered large. Since most photoelastic models are much larger than this, it is always necessary to use a system of lenses so that the light beam can be made large where it passes through the model and small where it passes through the polarizers. The presence of the lenses adds greatly to the expense of the equipment and tends to increase its overall dimensions. In this respect, the material

"Polaroid" has a tremendous advantage, since it can be used to produce a large field of polarized light without the necessity of a complicated lense system. Figure 2 shows an example of a modern type of polariscope, using Polaroid disks as the polarizers. The whole outfit is mounted on a base 2 × 4 feet, stands about 21 inches high, and its weight is only about 60 to 70 pounds, so that it can be transported very readily by two men. In fact, the polariscope is so compact that it has been conveniently put into the back of an automobile without dismantling any part of it. In spite of its light weight and small overall dimensions the apparatus has a clear field 12 inches in diameter, which is somewhat greater than that of the general run of polariscopes.

An interesting feature of this polariscope is the incorporation of quarter wave plates, which convert plane polarized light into circularly polarized light, as integral parts of the polarizing disks. For finding the directions of the principal stresses it is essential to use plane polarized light, but for photographic recording of the stress pattern this is inconvenient and leads to confusion due to the superposition of the isoclinic lines (lines giving principal stress directions) upon the fringe pattern. Fortunately the use of circularly polarized light eliminates the isoclinic lines without distorting the fringe pattern, so that this difficulty is easily overcome by placing correctly oriented quarter wave plates between the polarizers and the model. In this particular apparatus the model can be viewed in either plane or circularly polarized light, and in order to change from one kind of polarization to the other all that is necessary is to rotate each disk through 180° on its trunnions. With the arrangement as shown in Figure 2 the quarter wave plates are between the polarizers, so that the model is in circularly polarized light. Another convenient feature of this polariscope is the provision for rotating the plane of polarization. This can be accomplished by rotating each disk in its own plane (on the front of the apparatus one can see the knobs provided for this purpose).

Since the introduction of the synthetic resins, the invention of Polaroid has been the development of most consequence to Photoelasticity. Not only has this material reduced the cost of apparatus tremendously but in doing so, and through its advertising, it has attracted the attention of many investigators from schools and industry alike. This stimulation of interest has certainly borne fruit, as the progress which has been made in this field during the last two or three years has been truly remarkable.

The photoelastic method of stress analysis is primarily applicable to problems involving conditions of plane stress or to those three-dimensional problems which can be simplified to two dimensions. Several suggestions have been put forward for three-dimensional methods, but until recently all these have proved impractical. However, within the last three years two methods of considerable promise have been developed. One of these, the more recent, depends on the scattering

(*Continued to page 191*)

Figure 3.

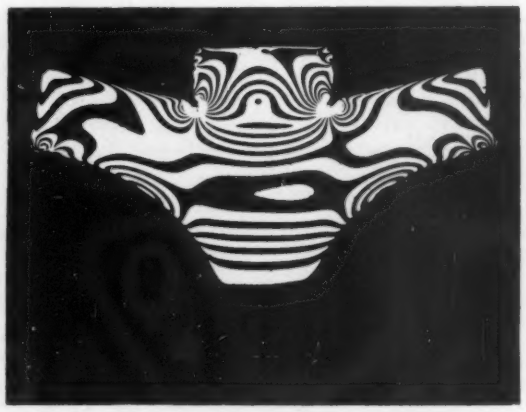
THREE DIMENSIONAL

Photoelastic Analysis of Stress Distribution

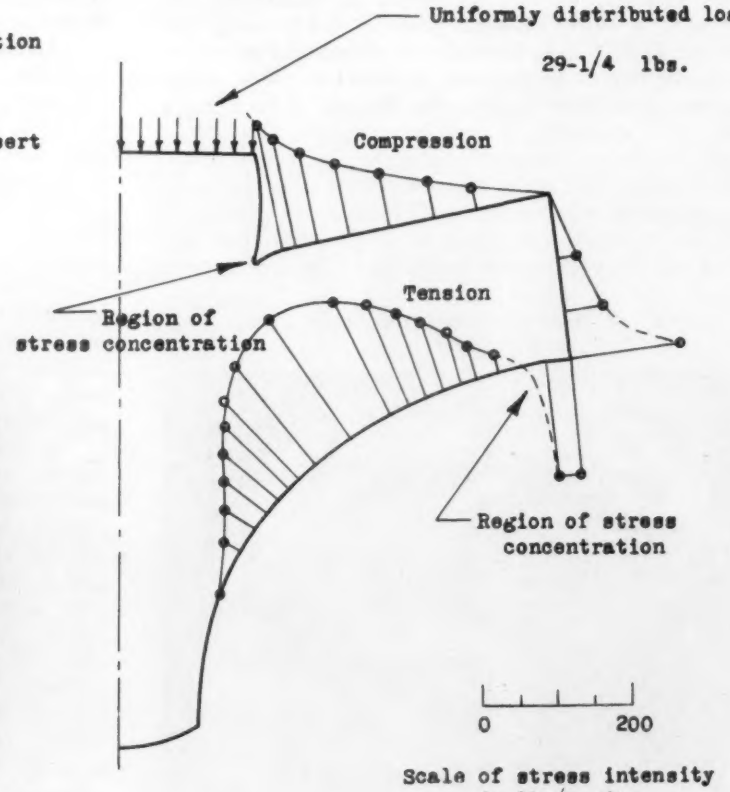
in a

Bakelite model of a Safety Valve Disc Insert

Thickness of slice containing the plane of symmetry .141"



Fringe Photograph



Fringe Constant - 3.34 lbs/in/order

United States Lines

ENGINEER'S PAY DAY

By R. L. SACKETT

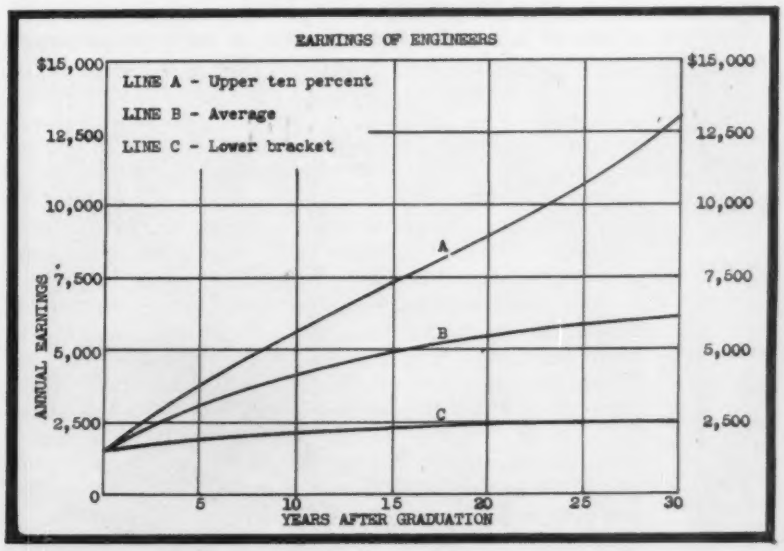
DEAN EMERITUS, PENN STATE

FEW questions concerning a profession are more difficult to answer definitely than, "What may I expect to earn in it?" Many personal qualities, particularly industriousness and native intelligence, the opportunities that come to pass, and the use made of them influence earning power so greatly that accuracy in predicting probable earnings of an engineer is impossible. Nor can anyone foretell what the situation will be in industry and business at any time in the future. Since business conditions of a period several years hence will largely determine earnings at that time, definite earning figures of the present or of the recent past are not indicative of the future.

In general, the beginning salary for the young engineering graduate is set at a fair living wage, regardless of the branch he follows. In cities where expenses are high some allowances are to be expected; accordingly, salaries there may run a little higher than elsewhere. The length of term or steadiness of employment also influences salary scales. Again, current industrial conditions affect the starting point, and, at the time that this is written, a shrinkage of salary appears even where employment remains on a steady level. This element is more or less transitory, and should not be given too much weight.

A man should not enter the engineering field solely for what he hopes to earn therein, but rather what he expects to put into it in life and service. His wage will then soon adjust itself to his ability. The young engineer, in his first few years of work, receives something far more valuable to him than money, namely the opportunity to improve his training, to perfect his use of the mental tools he has spent years in sharpening at college, and to increase his store of knowledge. The beginner may make or break himself during these early years by the earnestness or slothfulness with which he uses his opportunities. He is often unduly impressed by the fact that he occupies a lower place on the pay roll than the skilled laborers whom he assists in directing. He fails to realize that they have neither his aptitude for learning nor his probability for greatly increased earnings later. Nothing could be better calculated to blight a promising career than to allow opportunities for associations and for continued study to slip by. They should be considered as part of the wages of the beginner, and every possible advantage should be taken of them.

After about five years of experience, the engineering graduate has reached a point where he is definitely an individual. Differences in schooling vanish as experience and ability to make use of an education discloses the value of the person. The man able to take real pleasure in his work does his job far better than one who constantly must force himself to perform tasks



which are distasteful or uninteresting to him. The contented man is worth far more, for the products of his labors are of a higher quality than those of the drudge. Consequently, within a few years he is set

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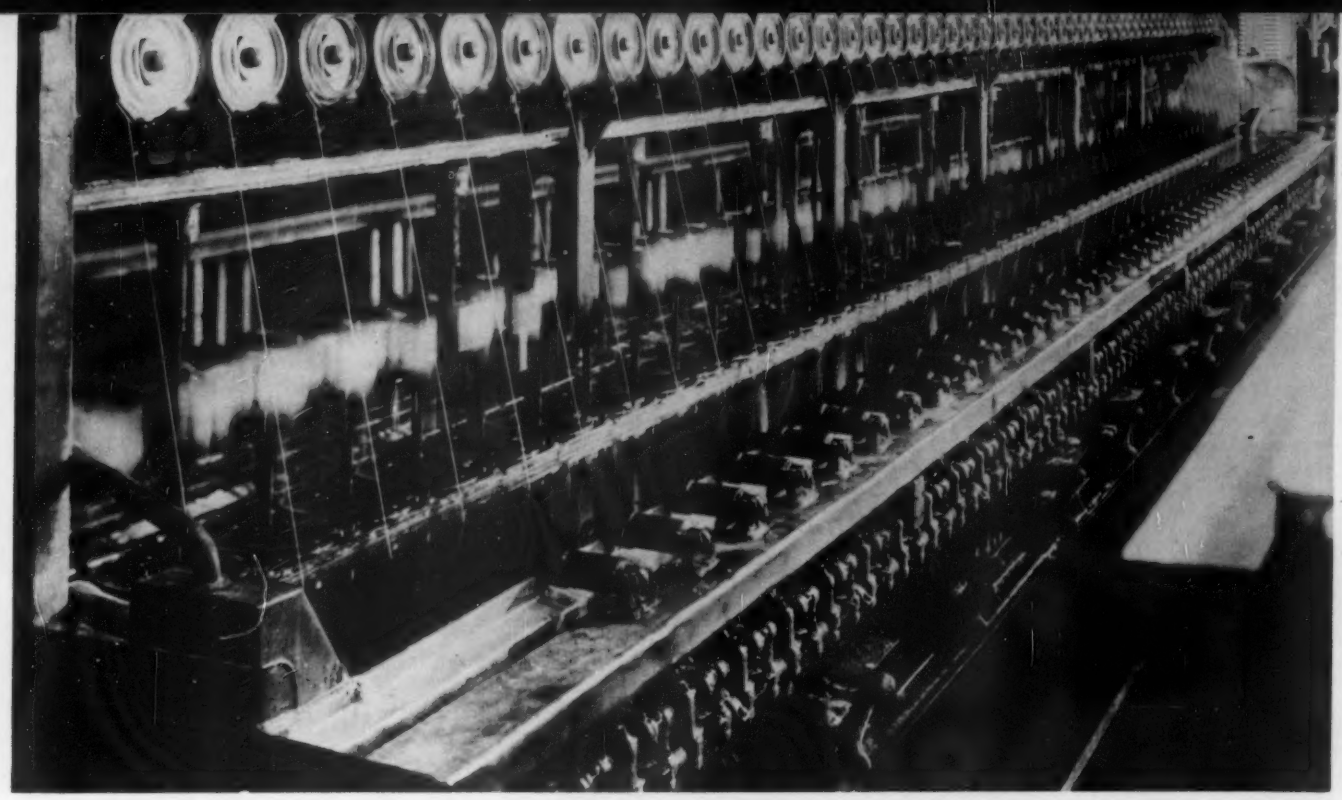

Du Pont

FROM TEST TUBE TO DRESS SHOP

FIRST RAYON AND NOW NYLON CHALLENGE THE SUPREMACY OF THE SILKWORM

By WILLIAM R. WILCOX

DURING the past twenty-eight years, the synthetic fiber industry has skyrocketed from the imaginative minds of a few far-sighted men to such proportions that the production of artificial silk now ranks high among the leading industries of the United States. The growth of rayon manufacture in particular is a story of phenomenal strides forward from the test tube to the dress shop. The last three decades have seen a chemist's discovery open up boundless fields in the entire textile industry. True, artificial silk has passed through all the stages of a young and healthy industry, but has done so with rapidity difficult to imagine.

The various effects of the new industry with its comet-like appearance on the economic horizon have been far flung. The amount of rayon used today is nearly six times that of silk. In the United States, production of 363,000 pounds of rayon in 1911 has risen to over 300,000,000 pounds in 1937. Japan has somewhat saved face in the textile world by placing synthetic fibers third on her list of exports to make up for the staggering drop in her silk market.

In 1937, well over 95 per cent of rayon was manufactured by the viscose and acetate processes in both world and United States production. The nitrocellulose process has been abandoned here, and there are but two producers of rayon by the cuprammonium method in this country. At present, the American Viscose Corporation is the largest producer of rayon in the world. Du Pont and the Celanese Corporation are second and third largest manufacturers in the United States.

Although the different techniques employed in the production of synthetic textile fibers result in a similar product, and are fundamentally the same, each entails chemically different processes which characterize that particular method of manufacture. Each process has been developed separately, and as new discoveries are made, the methods become increasingly dissimilar.

The raw material in the manufacture of the artificial yarns is alpha cellulose. Wood pulp and cotton linters have been found to be the most profitable sources because of a high alpha cellulose content and the absence of impurities which would affect the strength of the resulting rayon yarn. Thus all of the synthetic yarn manufacturers begin with the same raw material and end with a similar product. However, with the possible exception of the spinnerets, the remainder of the processing is entirely different.

The raw material in the manufacture of viscose-process rayon is principally wood pulp and some cotton linters. The wood pulp is in the form of sheets and is converted to alkali cellulose by the addition of caustic soda. Hydraulic pressure frees the resultant wet sheets of excess alkali and powerful grinders disintegrate the sheet into "crumbs." At this point, the cellulose is

packed into boxes in order that it may mature uniformly and absorb oxygen from the air. The "crumbs" are then conveyed to horizontal hollow drums where a carefully controlled amount of carbon bisulphide is introduced and the mixture is rotated. The action takes from three to four hours, at the end of which the "crumbs" have turned into an orange color and are known as the "Xanthate." The "Xanthate" next passes to a tank in which it is dissolved in water. It emerges as viscose. The solution is cooled, filtered several times to remove impurities and aged four days at constant temperature to attain proper "viscosity."

The solution is then conveyed to the spinning machines, where it is collected by small pumps and forced continuously through the minute openings in the spinneret into a coagulating bath of ammonium sulphate and sulphuric acid. The filaments thus formed are drawn out of the bath in a hardened form and wound. The yarn passes over a glass roller and is wrapped into the form of a hollow cake from which it is formed into skeins. The remaining chemicals are removed by a falling spray of soft, warm water upon skeins suspended on aluminum rods. The last traces of sulphur are removed by a hot solution of sodium sulphide. The skeins are finally hydro-extracted to remove excess water and then dried loosely. In this form they are shipped to the weaving mills and converted into a rayon yarn.

In the acetate process, the raw material is cotton linters. After the linters have been scoured, bleached, soured, and dried, they are converted into cellulose acetate by treatment with acidic anhydride, glacial acid, and sulphuric acid. The acetylation is performed in enamel-lined tanks. Di-acetate is formed by carefully controlled hydrolysis of the tri-acetate. The solution is re-precipitated as a white, flocculent mass by being poured into water. The compound, cellulose acetate, solidifies in the water and is then dried and bleached.

The cellulose acetate will be made into yarn but could just as well become a synthetic billiard ball, a roll of film, a purple toilet set, or a sheet of transparent wrapping paper. The cellulose acetate is dissolved in acetone and then filtered so carefully that all solids down to almost microscopic proportions are removed. Otherwise, the tiny nozzles of the spinning machine would clog. Thus purified, the solution is stored and later ready to be spun.

The spinning solution is a viscous yellow liquid about the consistency of maple syrup. The solution is forced downward through a spinneret which is housed in a tube through which a current of warm air rises. The acetone evaporates, is conducted away, and recovered as far as possible. A fine, silky filament remains. The number of nozzles in a spinneret depends upon the weight desired. An average weight is forty filaments. The filaments are gathered together and twisted into a single thread of yarn which is wound in a cap. In contrast to the other processes for manufacturing synthetic fibers, an increase in weight takes place, amounting to as much as sixty per cent of the original weight of the cotton linters.

The properties of acetate yarn which distinguish it from similar fibers are due to the fact that it is an acetic ester of cellulose rather than a regenerated cellulose. Practically only first quality yarn is produced, because imperfect skeins may be redissolved and respun. It was upon these distinctive properties of his product that Camille Dreyfus insisted that "Celanese" not be included under the general class of rayon.

It is interesting to compare the manufacture of synthetic textile fibers with the process by which the silkworm produces his valuable product. Both manufacturers and the silkworm use alpha cellulose as a raw material. The silkworm extracts it from mulberry leaves while industry obtains it from wood pulp or cotton linters. The processes leading to the spinning solution differ but the spinneret and the orifices in the silkworm's mouth are similar. The worm forms a solution which passes through two tubes which converge in the mouth. The substance is forced through two small openings and solidifies almost immediately upon contact with air. The industrial spinneret functions similarly with the exception that there are from twenty to one hundred holes in its metal cap. The silkworm's product still holds sway in the more expensive garments although synthetic fibers have conquered most of the lower priced clothes.

However, the position of silk may be further contested in the very near future by a new substance,

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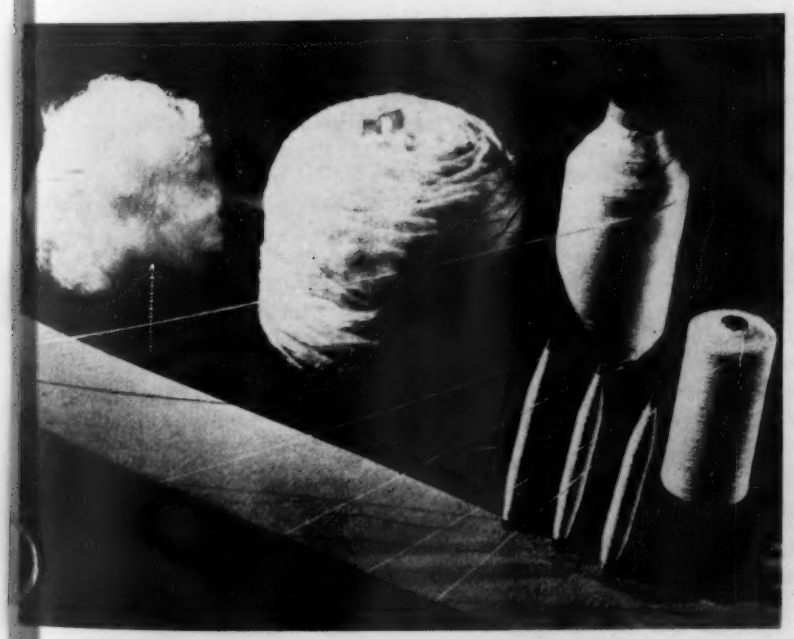

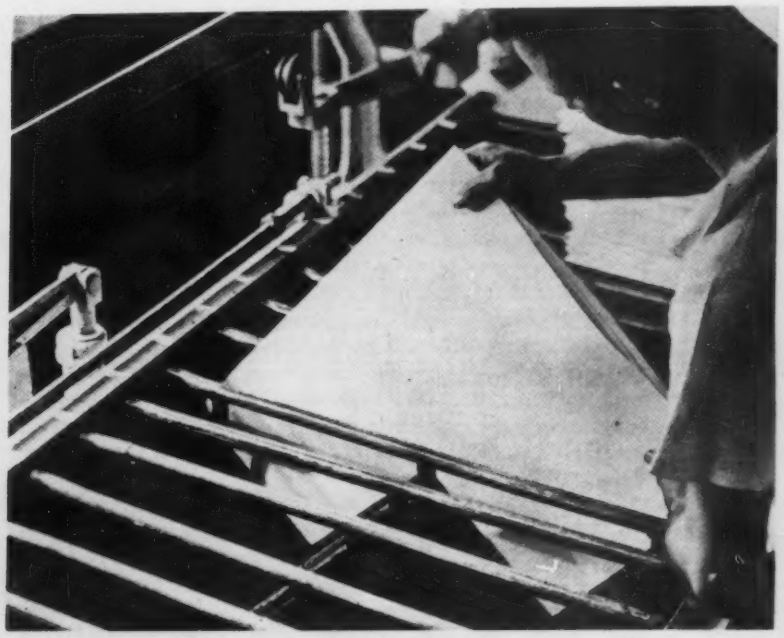

EDITORIALS

Early Paper Press, Dard Hunter Museum *T. E. N. Photo*

PAPER AND THE GRAPHIC ARTS

The new general study, The Arts of the Book, given for the first time during the second term of this year, is the most recent expression of a developing interest on the parts of students and staff at the Institute in the graphic arts. That the Institute provides an environment in which such an interest can thrive has been amply demonstrated. On the scientific side, many important contributions have been made to the printing art, particularly through the work of Professor Arthur C. Hardy in the fields of photography, color analysis, and printing inks. The establishment of the Dard Hunter Paper Museum has brought to the Institute not only the greatest collection in the world on the history of paper making, but Mr. Dard Hunter himself, a man of rare scholarship, taste, and skill in the graphic arts.

In another direction we have had in recent years the stimulation of Mr. Samuel Chamberlain, the distinguished artist, who has gathered about him an enthusiastic group of students who wish to start their apprenticeship in the making of prints, particularly etchings, dry points, and lithographs. This of course is related to the broad training in the arts which is an integral part of the curriculum of the School of Architecture.

Still another expression of the interest in fine printing may be seen in the activities of the Friends of the Library, who are gradually establishing in the library of the Institute, a collection of works outstanding from the point of view of the graphic arts, who have sponsored a student contest in book collecting, and who bring to the Institute from time to time some of the fine exhibits prepared by the American Institute of Graphic Arts.

In its publications, the Institute has some very excellent examples of fine printing. TECH ENGINEERING NEWS itself has been recognized many times as an outstanding example of magazine layout and typography among student publications, and last year our yearbook, "Technique," won national honors in competition with other college annuals. Outside the undergraduate field, we have the *Technology Review*, which occupies among college and scientific magazines a distinguished place as a skillfully designed and printed magazine.

With these many evidences of interest and of competence in the graphic arts, it is not surprising that there is a demand for recognition of the printing art in the Institute curriculum. The establishment of the general study, The Arts of the Book, provides this recognition. This course is presented under the direction of Professor Henry Seaver of the Department of Architecture, who, besides his wide scholarship in the history of art, is a skillful artist himself, a maker of prints, and a printer of taste with his own press. Associated with Professor Seaver in giving the course are Professors Hardy, Burchard, Fassett, Mr. Dard Hunter and others, each contributing some special competence to round out a course coöperatively presented and therefore of breadth and variety.

The content of the course will include a study of paper, type, and printing plates, their history and effective combination to produce appropriately designed printed material. Among the topics treated are the history of fine printing, type nomenclature and specification, page and display layout, use and reproduction of illustration, modern type setting and press work, estimation of printing costs, preparation of manuscripts, and seeing them through the press. Students in the course will have an opportunity to utilize the facilities of the Dard Hunter Paper Museum. From time to time there will be exhibits of typographical techniques and products.

The course is designed to appeal to many students, particularly to those who may some day deal with the graphic arts either as authors, or publishers, or as engineers in the printing industry, or to those who desire to develop their appreciation of printing as an art. In being directed at these groups, the course has wide cultural as well as practical value. From every aspect the course is in the best tradition of collegiate participation in the graphic arts which began with Caxton's introduction of printing into England and the almost simultaneous founding of the Oxford University Press, which together with the Cambridge University Press founded in the following century, has made so many notable contributions to fine printing.

J. R. KILLIAN, JR.

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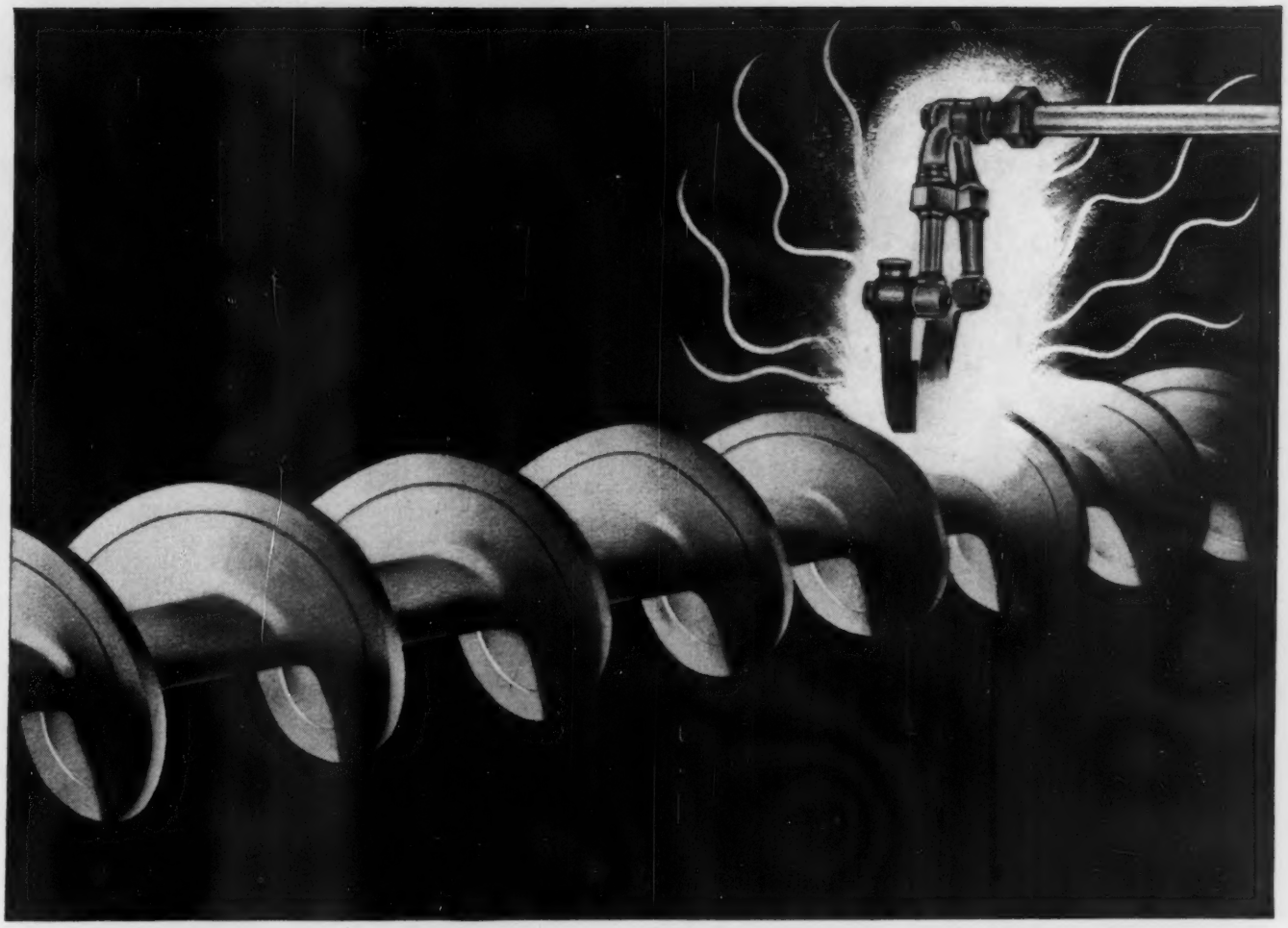

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FROM TEST TUBE TO DRESS SHOP

(*Continued from page 185*)

called nylon, which has been under development in the duPont laboratories. A year ago last September, some light was thrown upon the mysterious "Fiber 66" when two patents were assigned to the du Pont company. The patent claims disclosed that the new material could not only be drawn into fibers of lustrous and silky appearance, but could also be used for brush bristles, racquet strings, fishing lines, leaders, and plastic compositions.

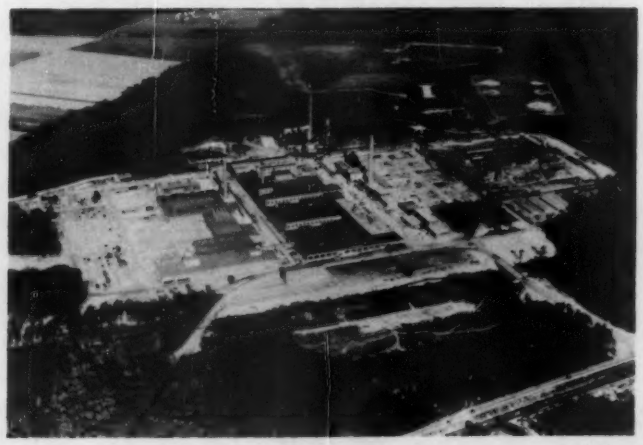
The chemistry involved in the production of nylon is highly complicated and the details of the processing are being kept secret by the manufacturers. The new substance contains carbon, hydrogen, oxygen, and nitrogen. These elements are derivable from such common raw materials as coal, water, and air. Du Pont has been conservative in publicizing the physical characteristics of nylon, but it is reported to have even greater elasticity than silk and to take dyes readily.

It is expected that the cost of nylon will range between that of rayon and silk so that the remaining silk market in the United States will almost disappear. If the price lies close to silk, nylon will probably not compete very strongly with rayon initially. In any event, neither rayon nor silk will be threatened seriously for another three months. Nylon is already on the

Testing rayon to determine weight

Du Pont

Du Pont rayon plant at Richmond, Virginia



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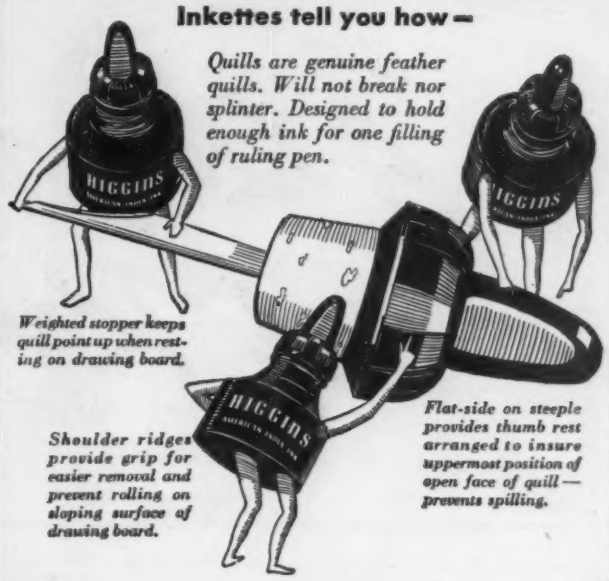
Quills are genuine feather quills. Will not break nor splinter. Designed to hold enough ink for one filling of ruling pen.
Weighted stopper keeps quill point up when resting on drawing board.
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market in the form of toothbrushes but will not enter the hosiery field until sometime in April, when stockings bearing the stamp, "Nylon," will be released simultaneously throughout the United States.

At this point it is difficult to estimate the effects which will be caused upon the introduction of the new polyamide yarn. Japan stands to lose most of her remaining silk exports to the United States if nylon is successful. The rayon producers also will be affected: adversely if nylon prices are reduced to a level competitive with cellulose fibers; constructively if the rayon makers are able to develop similar fibers or are licensed to produce the du Pont product, and if they are able to invade the hosiery field.

Nylon yarn being processed

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A Quiz for buyers of Railway Cars

Q What is SHOTWELD* ?

A SHOTWELD* is a registered trade name applied to a process of welding stainless steel, to the welding equipment used and to the welded constructions.

Q What does the SHOTWELD* process do?

A It controls the factors of time, current and pressure and records the result so that a sound weld is insured, a weld which does not impair the strength of the metal in the vicinity of the weld or render it subject to corrosion.

Q What are some of the exclusive features of the SHOTWELD* process?

A (a) Welding stainless steel with a current so high in a time so short that the strength of the metal is preserved and harmful carbide precipitation avoided.

(b) The weld recorder—an instrument which constantly compares the heat input of each weld made with a predetermined standard and records the result on a paper tape.

Q Why is the SHOTWELD* process essential?

A Because strength and safety requirements demand that every element of risk in the building of a railway car be eliminated—that *every* weld be a sound weld, and remain so.

Q What is the strength of a weld made by this process?

A The material in the weld has a tensile strength of 90,000 pounds per square inch and 65% elongation. The shear strength is substantially twice that of an ordinary steel rivet of the same diameter.

Q Is SHOTWELD* an accepted process?

A Yes. Its record, after ten years of application, both in normal use and in accident, confirms the fact that no weld made by the SHOTWELD* process has ever failed or contributed to a failure.

Q What is the best proof of the reliability of the SHOTWELD* process?

A The hundreds of Budd-built, stainless-steel railway cars that are now in successful operation all over the country.

Q Who controls the SHOTWELD* process?

A The SHOTWELD* process was developed and is owned and controlled by the Edward G. Budd Manufacturing Company, Philadelphia.

Q What other car builders can use the SHOTWELD* process?

A The Budd policy is to make the SHOTWELD* process available to responsible car builders under licensing arrangements.

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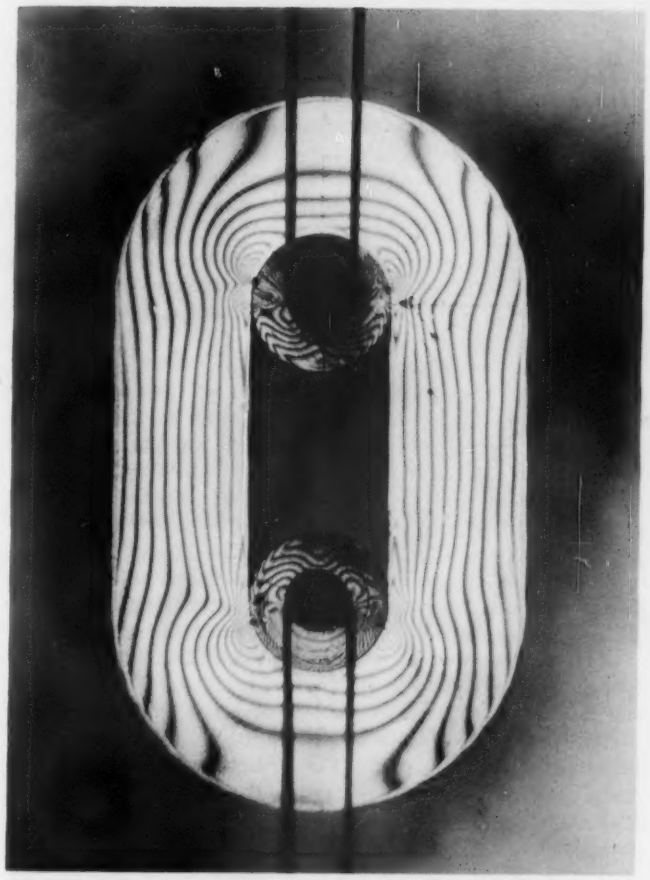

Stress Pattern of Bakelite Specimen

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VISIBLE STRESS

(*Continued from page 182*)

of light within the model, and the other, which is much farther developed, depends upon certain peculiar thermal properties of bakelite.

The underlying principle of the "fixation method" or freezing method, as it is sometimes called, depends upon the ability of bakelite to retain a permanent set and the photoelastic effect if subjected to the proper conditions of stressing and heat treatment. At normal room temperatures this material has a modulus of elasticity of about 620,000 pounds per square inch and a fringe constant of about 87 pounds per inch per order. However, if the temperature is raised, the numerical values of these quantities drop very noticeably. At 230°F. the modulus has dropped to about 1,100 pounds per square inch and the fringe constant is 3.34 pounds per inch per order. At this temperature the material is truly elastic and will immediately assume its complete deformation upon application of load, or conversely it will immediately recover its original condition upon release of load. If a bakelite model is loaded at this elevated temperature (230°F.), the deformation will be relatively large due to the low modulus. Now, if the model is slowly cooled to room temperature and the load removed, due to the difference in modulus of elasticity, it will recover only 1/640 part of the deformation which was imposed upon it at the elevated temperature. It is also found that the material retains the photoelastic effect which it had at the elevated temperature (less 1/640 part), and furthermore it can be cut up into slices and each slice will retain its own photoelastic effect provided that the cutting operations have not raised the temperature. This is very convenient indeed, as one can cut a slice from the interior of the model and determine the state of internal stress.

Figure 3 shows how the method may be applied to an actual problem. In this case the model represents the circular stopper in a safety valve. The process consisted of loading the bakelite, heating and cooling it slowly and then cutting out a slice (.141 inch in thickness) whose mid plane contained the plane of symmetry of the model. The fringe photograph and the corresponding stress analysis are given in the illustration. It should be mentioned that this particular case is ideally suited to this method, since the slice was made to contain one of the principal planes.

If one takes a look at the future to see what possibilities are in store for Photoelasticity, one can see that undoubtedly it will be applied to numerous dynamic problems. These fall into three major classifications: (*a*) those problems in which the stress is produced by dynamic effects but does not vary with time (as in the case of a disk rotating at constant speed), (*b*) the cases in which the stress condition is transient and disappears in a very short interval of time (impact), and (*c*) the cases in which the stress condition is cyclical and repeats itself at regular intervals of time.

Into the third classification fall all kinds of problems in vibration. A particular application of the photoelastic analysis is shown in Figures 4 and 5. These illus-

(*Continued on page 193*)

ENGINEER'S PAY DAY

(*Continued from page 183*)

apart from the group, and his earnings depend more upon his own productive ability than upon any scale of salaries.

Engineering incomes have undergone several changes in the last ten years. Before the depression, employment was continuous and available to practically all those who wished to work. With the reduced industrial activity of the thirties, however, this condition changed rather sharply, and considerable numbers of engineers were without work. Studies of data on 52,589 engineers by the United States Bureau of Labor Statistics indicate that, at its worst, about eleven per cent of those who rated themselves as engineers were not employed. Over a period of five years, from 1930 to 1934, approximately one-third of these engineers reported some period of employment.

In 1936–37 there occurred an encouraging upward trend of occupation, which in early 1938 reversed itself abruptly. These conditions have had marked effects upon the incomes of engineers and on all professional men, both by lowering rates of remuneration and by interrupting earnings.

Many studies of engineering incomes have been made in the past two decades with varying results and implications. Those of the current studies of the Federal Bureau of Labor are clearly too low for normal conditions, because they cover the years 1929 to 1934 which were far from standard, and because no check has been possible upon the fitness of the rating as "engineers" of all those who so classify themselves in their replies.

The effects of the depression period we have been experiencing may be roughly characterized as having reduced by fifty per cent the average normal incomes of engineers at the lower levels and by twenty-five per cent those at the upper levels. Of course, some incomes were reduced to zero in this process. Even then, engineering employment did not suffer as much as other professions, mainly because of the application that engineering has had in some of the recovery programs.

It must be recognized that whatever the results obtained for any given period, those figures may not be used with any great certainty to predict for later years. Economic conditions change. Professional opportunities shrink or expand. Shifts occur among the fields within a profession. The popularity of any work may change enough to affect the number of new entrants into those fields. All these factors influence salary rates and the stability of employment.

Collecting those items which seem to be borne out by the several studies, however, we may venture to show a few salary figures and make a few general statements:

The more successful engineers and those promoted to managerial positions continue to increase their earnings until late in life. The upper ten per cent of engineering incomes, under normal conditions, may reach $12,000 per annum or more. For an engineer of average success we may expect his income curve to rise from a beginning point of from $1,200 to $1,800 to a maximum of $5,000 to $7,500 at the age of sixty or sixty-five years. For those less fitted by training, temperament, or other factors, incomes level off to $2,500 per annum or less at ages from forty to fifty.

The Bureau of Labor states that "there can be no question but that the best of a group of skilled wage earners are in a better economic position than those who struggle to maintain a position on the fringes of the engineering profession." The differences between the earning capacities of men of experience in this profession are principally due to the ability of the higher paid men to combine with their technical ability a capacity to manage men and affairs.

The average income of engineers should not be the determining factor in deciding to enter an engineering college on the way to that profession or to other work where such an education is an advantage. Rather, consider natural aptitudes and interests. A definite interest in the foundation subjects of mathematics, physics, chemistry, and making things is important. A determination to persevere through difficulties is also necessary. With these qualities and a fundamental engineering education a young man is well equipped to strive for success in the field which holds the greatest interest for him.

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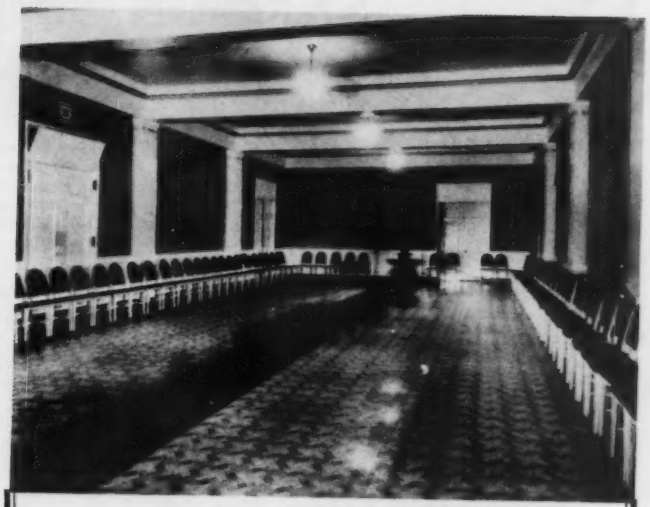

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Activity Leaders . . .
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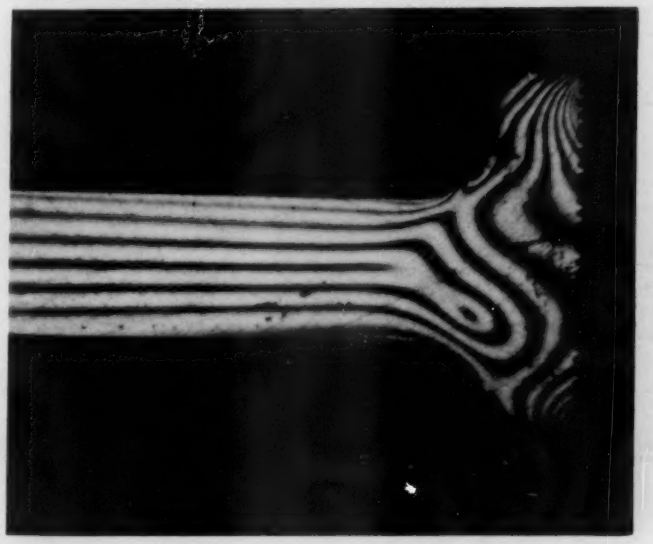
WALKER MEMORIAL

VISIBLE STRESS

(*Continued from page 191*)

trate the fringe pattern in a cantilever beam vibrating at its resonant frequency of 51 cycles per second and the apparatus used to produce the vibration. The vibrator consists of a pair of equal weights revolving in opposite directions around parallel shafts in such a manner that the horizontal components of the unbalanced forces cancel out and the vertical components add up to give a sinusoidal fluctuation. This is merely a simple example of what may be done in studying dynamic stress conditions, and although some investigations have been attempted in all three classes there still remains an almost untouched group of fascinating problems to be undertaken by men with patience and ingenuity.

Figure 5. Vibrator with Specimen Mounted



EDITORIALS

(*Continued from page 186*)

NEUTRALITY & RADIO AMATEURS

The war in Europe has made a noticeable change in the operating of the American Radio Amateur. At the outbreak of the war, all amateur operating in belligerent and in some neutral nations ceased. At that point, the fate of amateur activity in this country hung in the balance, and it was only through a rigid, self-imposed observance of neutrality that amateur radio was preserved. The rules as laid down by the American Radio Relay League and later amplified by a warning from the Federal Communications Commission are: to avoid communication with belligerent or unlicensed stations, to confine international contacts to discussions of experiments, and to refrain from discussing the war or voicing personal feelings over the air. By strict adherence to these regulations, American amateurs are neutral — they neither convey military intelligence nor serve as a barometer of United States public opinion.

There are at present no more than two countries in

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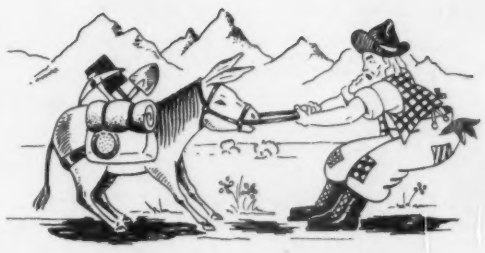
Europe which permit amateurs to operate. Indeed, at least three-fourths of the foreign amateurs have been silenced. In many countries, equipment was confiscated and licenses were revoked. Amateurs throughout the world, even in the possessions of warring nations, were also shut down. South America remains untouched, however, providing the best foreign contacts for our amateurs. The effect of the scarcity of long-distance communication has been to direct increased interest to other fields. Some amateurs have turned to "rag-chewing" or "traffic-handling" as an outlet for their endeavors. Others, more serious-minded, are working on emergency equipment or investigating still further the ultra-high frequencies.

The amateur has one advantage over most people. He has friends on both sides of the conflict and may therefore be neutral in thought. He is not swayed by propaganda, since, through these friends, he realizes that the ordinary people of all countries desire peace. Thus, it is the task of the American Radio Amateur to observe neutrality and keep open the bands of communication in order that he may renew his friendships sometime in the future when peace shall come.

G-E Campus News



GOLD RUSH

IF YOU talked to an old-time prospector, he would probably tell you that while burros are more than a little aggravating at times, they are also very handy animals. For when it comes to carrying paraphernalia ranging from pick axes to flour and bacon, they're tops.

But good as burros can be, they haven't a chance in modern large-scale mining operations; they're completely out in the cold. Electric shovels and dredges, for example, are part of one California company's equipment. Scooping out the pay dirt in great gulps, the shovel dumps it into barges containing the recovery machinery—and there's the gold.

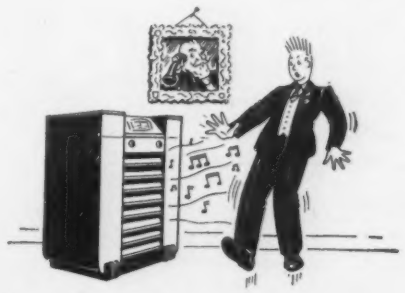
Aiding such modern miners are G-E engineers, Test men and ex-Test men alike. For this particular job they supplied a motor-generator set, a hoisting motor, and various control and auxiliary units. What chance has the lowly burro?

PAINTED WITH LIGHT

STONE elephants and ball parks, athletic fields and tunnels may seem to have absolutely nothing in common, but they do. They are typical of the diverse things that have been painted with light by G-E illuminating engineers under A. F. Dickerson, Texas A. & M. '10 and ex-Test man, manager of the illuminating laboratory.

These engineers are particularly fond of lighting bridges. San Francisco's great Bay bridge and towering Golden Gate bridge were two of their favorite assignments. Now they have another unusual span to illuminate—the world's longest floating bridge, a 1¼-mile pontoon structure being built across Lake Washington near Seattle.

Sodium lights will illuminate the bridge proper, which consists of 25 precast, reinforced-concrete pontoons, 350 feet long and 59 feet wide. Anchored by cables to the lake bottom, they float seven and one-half feet out of water.



GHASTLY REALITY

THE citizens of Schenectady, General Electric's headquarters, have long been looking at the giant that is radio and saying, "I knew him when!" For G-E radio engineers have made scores of important contributions to radio progress. Now they are giving Schenectadians something new to boast of in a radio way. These engineers, headed by C. A. Priest, Maine '25 and ex-Test man, will soon put in operation a station based on the revolutionary "frequency modulation" system of broadcasting developed by Edwin H. Armstrong. Among the features of this new system are extremely high fidelity, better signal coverage, and virtual elimination of static. In fact, so life-like was a recent demonstration broadcast that an English journalist simply said, "It was ghastly in its reality."

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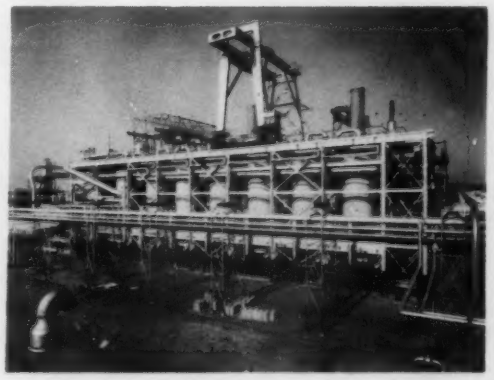

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